

Screening for thoracoabdominal aortic aneurysms in patients with aortoiliac atherosclerosis: a preliminary study

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Thoracoabdominal aortic aneurysms (TAAs) usually present with rupture and carry a high morbidity and mortality rate. Early detection of TAAs with screening methods and elective surgical repair could potentially diminish these complications. The present study was aimed at screening for TAA in patients with angiography-proven aortoiliac atherosclerosis (n = 43). A group of patients without aortoiliac atherosclerosis was used as controls (n = 15). Age, sex and aortic diameter at the level of the T12 vertebra were recorded. The subjects were divided into two age categories, the first made up of those aged less than 65 years and the second those aged 65 years or more. A T12 aortic diameter greater than 35 mm was used to indicate TAA. Statistical analyses were performed by independent t-test and general linear model with age category, sex and atherosclerosis as factors. The mean T12 aortic diameters were greater in patients with atherosclerosis than in the control group (25.2 ± 5.0 vs. 22.9 ± 2.4 mm; p = 0.034). Two out of 43 patients (4.7%) with aortoiliac atherosclerosis had TAA, while no one in the control group had TAA. A general linear model showed that the interaction of age category and sex significantly affected the T12 aortic diameter [F (1.49) = 4.044, p = 0.050]. Post hoc (LSD) tests revealed that male patients aged over 65 had greater T12 aortic diameters than other patients. We conclude that patients with aortoiliac atherosclerosis may be at greater risk for developing TAA. Ageing and male sex may also be associated with thoracoabdominal aortic enlargement. (Folia Morphol 2008; 67: 78–83)

Key words: aneurysm, angiography, aortoiliac atherosclerosis, thoracoabdominal

INTRODUCTION

An aortic aneurysm is defined as localised artery dilatation greater than 50% of the expected normal luminal diameter. Aneurysms that extend from the descending thoracic aorta into the abdomen are clas-

sified as the thoracoabdominal variety. Thoracoabdominal aortic aneurysms (TAAs) are uncommon and usually present with rupture. TAAs constitute approximately 2–5% of all degenerative aortic aneurysms [9]. The estimated incidence is six cases per

100,000 patient years [8]. The surgical treatment of TAA remains one of the most formidable challenges in vascular surgery, and emergency repair of its rupture is a complicated operation with a high mortality rate [6, 9, 20, 26]. During recent decades considerable progress has been made in the reduction of morbidity and mortality through elective TAA repair. However, since no appropriate screening programmes are routinely performed, many TAAs remain silent until rupture, and this fact has contributed to the high mortality rate of patients with TAAs. Hence it would be advantageous to identify patients with TAA by a screening method. Early detection of TAAs could be of the utmost importance and elective surgical repair would potentially prevent the serious consequences of their rupture [19].

The risk factors for atherosclerosis and aortic aneurysms overlap. Aneurysms mainly occur at older ages, and it is known that aneurysm formation is a long-term complication of the atherosclerosis process [1, 32]. Previous studies have found an association between aortic aneurysms and coronary artery disease [28, 30]. However, to the best of our knowledge, the relation between peripheral vascular atherosclerosis and TAA has not previously been investigated. The present study aimed at screening for TAA in patients with atherosclerotic aortoiliac occlusive disease who had undergone angiography. The effects of age, sex and aortoiliac atherosclerosis on the thoracoabdominal aortic diameter were estimated by means of a general linear model.

MATERIAL AND METHODS

Forty-three patients with aortoiliac atherosclerosis, who had been examined with conventional angiography in Tabriz between the years 2001 and 2006, were retrospectively studied (the atherosclerosis group). The age and sex of each patient were recorded. In the atherosclerosis group ($n = 43$) the mean age of the patients was 61.2 ± 10.7 years (range 40–91) with a male to female ratio of 40 (93%)/3 (7%). These patients suffered from symptoms and signs of lower limb ischaemia. Angiographic findings revealed numerous atheromatous plaques and also narrowing or complete occlusion along the lower aortic segment and iliac arteries. The angiography was performed through the left brachial or axillary arteries by a percutaneous procedure. The catheter was guided to the aortic arch and descending aorta, and the angiograms were obtained following the first injection of a contrast medium into the middle part of the thoracic aorta

and the second injection into the proximal part of the abdominal aorta. X-ray films were obtained in the anteroposterior view.

All patients derived from the atherosclerosis group were classified according to the TransAtlantic InterSociety Consensus (TASC) statement on the treatment of peripheral vascular disease [22, 25]. According to the TASC classification for aortoiliac occlusive disease, iliac occlusions can be stratified as B, C and D lesions. TASC-B lesions include unilateral common iliac occlusion only. TASC-C iliac lesions include unilateral external iliac occlusions that do not extend into the common femoral artery or bilateral common iliac occlusions. TASC-D lesions are bilateral external iliac, ipsilateral common and external iliac occlusions, or diffuse disease of the aorta and both iliac arteries. All the patients examined in our group were classified as TASC-D patients. According to the Crawford classification of thoracoabdominal aneurysms, in all types of TAA the aorta is enlarged above the renal arteries at the level of T12 [10]. Thus the diameter of the aorta was measured at the level of T12 in all patients. A diameter greater than 35 mm at the level of T12 was used to indicate a TAA [5, 13].

Fifteen patients without aortoiliac atherosclerosis were used as controls. All had undergone angiography of the aorta and its branches for reasons such as kidney donation or other presumed intra-abdominal vascular pathologies, including renal artery stenosis, gastrointestinal bleeding and mesenteric artery disease. The main rule of eligibility for the control group was that they had to be negative to the TASC classification and show no symptoms and signs of peripheral vascular disease. In the control group ($n = 15$) the mean age of the subjects was 50.8 ± 19.0 years (range 30–88 years) with a male to female ratio of 12 (80%)/3 (7%). All the subjects were divided on the basis of their age into two categories: those aged below 65 years ($n = 38$, age category 1) and those aged 65 years or more ($n = 20$, age category 2).

Data were presented as the mean \pm standard deviation. Statistical analyses were performed by means of SPSS for Windows version 13 using Fisher's exact test and an independent t-test. Pearson's correlation tests were used to estimate the correlation between T12 aortic diameter and age. A general linear model was designed to assess the independent effects of aortoiliac atherosclerosis, age category and sex, as well as their interactions on the T12 aortic diameter. Post hoc tests were

Table 1. Characteristics of patients with aortoiliac occlusion (aortoiliac atherosclerosis group) and control group

	Aortoiliac atherosclerosis group	Control group
Age (years)	61.2 ± 10.7	50.8 ± 19.0
Sex (male/female)	40/3	12/3
T12 aortic diameter [mm]	25.21 ± 5.0	22.9 ± 2.4
Thoracoabdominal aortic aneurysms	4.7%	0%

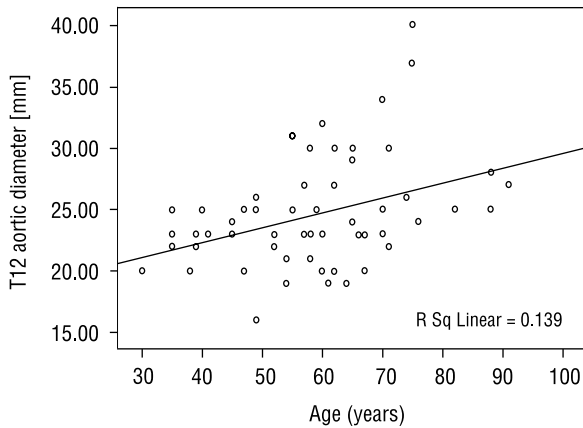


Figure 1. Scatterplot showing the association between age and T12 aortic diameter.

performed with LSD. A p value less than or equal to 0.05 was considered to indicate statistical significance.

RESULTS

No differences were found between the two groups with regard to age (t-test, $p = 0.06$) and gender ratio (Fisher's exact test, $p = 0.172$). Table 1 shows the characteristics of the two groups. A significant direct relationship was found between T12 aortic diameter and age in all subjects ($r = 0.373$, $p = 0.004$) (Fig. 1).

Two out of 43 patients (4.7%) with aortoiliac atherosclerosis had angiographic evidence of TAA (with a mean T12 aortic diameter of 38.5 ± 2.1 mm), while no one in the control group had TAA. The mean T12 aortic diameters in patients with aortoiliac atherosclerosis and in the control group were 25.21 ± 5.0 and 22.9 ± 2.4 mm respectively (Fig. 2, 3). The T12 aortic diameter was significantly greater in patients with aortoiliac atherosclerosis than in controls (t-test, $p = 0.034$). A general linear model (Table 2, Fig. 4) revealed that the interaction of age category and sex significantly affected the T12 aortic diameter [$F(1.49) = 4.044$, $p = 0.050$]. Post hoc tests revealed

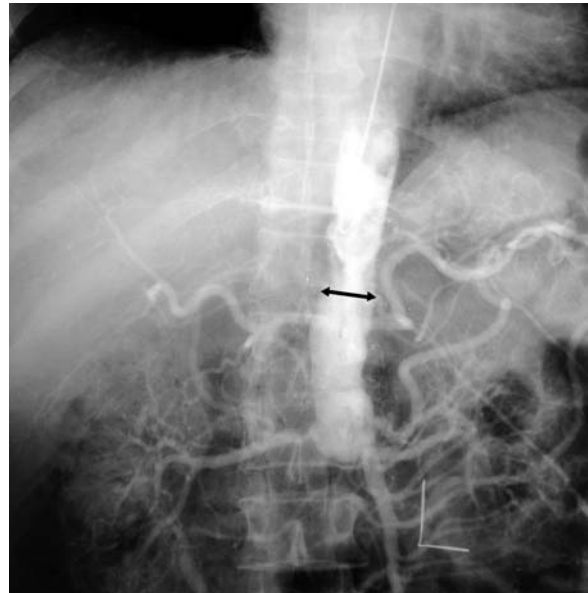


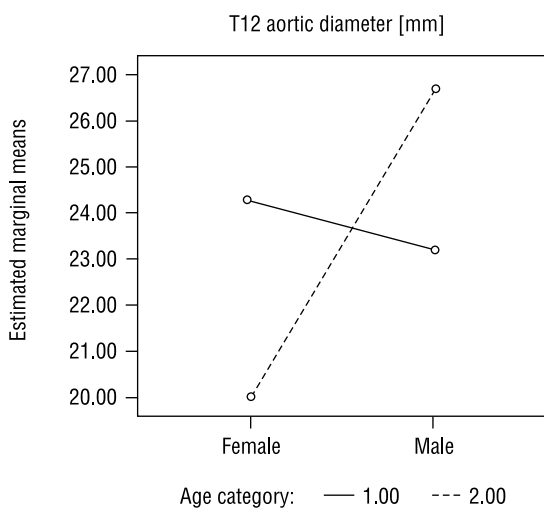
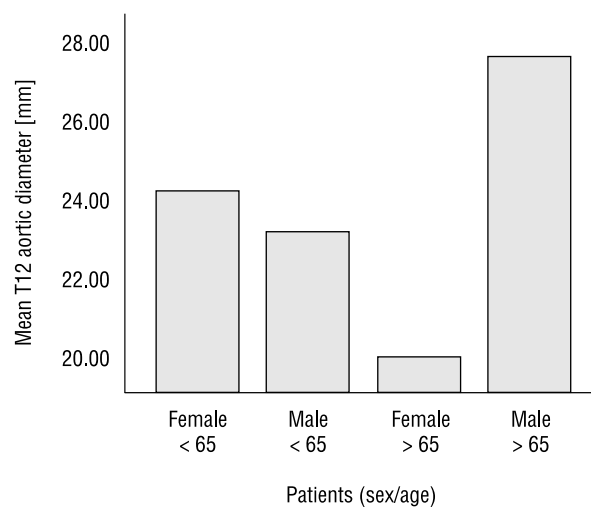
Figure 2. A complete aortoiliac occlusion without thoracoabdominal aneurysm (two-sided arrow, T12 aortic diameter).



Figure 3. A complete aortoiliac occlusion with thoracoabdominal aneurysm (two-sided arrow, T12 aortic diameter).

Table 2. General linear model with T12 aortic diameter as dependent variable. Model $r^2 = 0.30$; *indicates interaction

	Mean square	F	P
Sex	34.854	2.110	0.153
Age category	0.716	0.043	0.836
Atherosclerosis	35.553	2.152	0.149
Sex*Age category	66.802	4.044	0.050
Atherosclerosis*Age category	10.265	0.621	0.434
Atherosclerosis*Sex	9.342	0.565	0.456
Atherosclerosis*Age category*Sex	33.817	2.047	0.159

**Figure 4.** The interaction of sex and age category in prediction of T12 aortic diameter as indicated by crossing lines in general linear model plot.**Figure 5.** Bar chart comparing the mean T12 aortic diameter across sexes and age categories.

that male patients aged over 65 had a greater T12 aortic diameter than corresponding females ($p = 0.018$) and males aged below 65 ($p = 0.001$, Fig. 5).

DISCUSSION

The results of this study showed that 4.7% of patients with aortoiliac atherosclerosis had angiographic evidence of TAA. T12 aortic diameter was significantly greater in patients with aortoiliac atherosclerosis than in controls. Irrespective of atherosclerosis, the interaction of sex and age category significantly affected T12 aortic diameter, indicating that male patients aged over 65 years had greater aortic diameters than other patients. As the natural history of TAAs is of progressive dilatation to eventual rupture, more than half the deaths in patients with TAA are secondary to aneurysmal rupture [4, 7, 23, 24]. Hence early diagnosis and surgical

treatment are mandatory in preventing rupture [11, 12, 23]. Besides the surgical difficulties, repair of ruptured aneurysms is associated with temporary interruption of blood flow to the kidneys, viscera and spinal cord.

Peripheral arterial atherosclerosis is present in 17% of individuals between 55 and 70 years of age, with the femoral and aortoiliac arteries being most commonly involved [9]. As atherosclerosis indicates a diffuse vasculopathy, it is always important to consider concomitant vascular lesions in patients with peripheral arterial atherosclerosis. Atherosclerosis accounts for more than 95% of abdominal aneurysms, while about half of patients with thoracic aneurysm or TAA have associated atherosclerosis [2]. TAA patients may also have associated coronary, renal and cerebrovascular arterial atherosclerosis. Disseminated peripheral atherosclerosis may also occur in TAA [21].

The growth of the elderly population is likely to result in a further increase in the incidence of aortic aneurysms, including TAA. This suggests that more diagnostic efforts should be focused on aortic aneurysms and that high-risk populations should be identified for early management. Considering the low frequency of TAA in the general population, the observed 4.7% prevalence in patients with aortoiliac atherosclerotic disease highlights a clinically important situation. The association between TAA and aortoiliac atherosclerosis could be attributed to the fact that a lesser degree of atherosclerosis, insufficient to cause significant occlusion, might involve the thoracoabdominal aorta. Oxygen and nutrient supply to the outer half of the aortic wall is provided by the vasa vasorum, while that to the inner part is by diffusion from the aortic lumen. Atherosclerosis resulting in intimal thickening might impair the diffusion mechanism and involve the vasa vasorum. These changes may then result in internal ischaemia and degeneration of elastic components, predisposing the aorta to aneurysmal formation.

From an anatomical point of view, the most important structural element of the aortic wall is the media. It consists mainly of smooth muscle cells with elastic layers in a collagen network [14]. Although elastin provides arterial wall distensibility on pulse propagation, the collagen contributes tensile strength and prevents overdistension. Most aortic aneurysms are found in the infrarenal aortic segment [27]. Several observations may help to explain this predilection. In the normal aorta there is a gradual but substantial reduction in the number of medial elastin layers from the proximal thoracic aorta (60–80 layers) to the infrarenal aorta (28–32 layers) [18, 31]. Associated with this structural change is a reduction in both collagen and elastin content from the proximal to the distal aorta. Furthermore, a significant decrease in elastin content between the suprarenal and the infrarenal aorta has been described. It was noted that the infrarenal aortic segment is the only location within the aorta where the proportion of elastin decreases relative to collagen [18]. Compared to the abdominal aorta, the thoracic aorta has a significantly higher elastin and collagen content and a lower collagen-to-elastin ratio [15]. VSMCs in the ascending aorta originate from the neural crest, while those in the descending and abdominal aortas originate from mesoderm and endothelial cells [3, 16]. The differences in the physical structure of thoracic and abdominal aortas may con-

tribute to the differences observed in the pathogenesis of TAAs and AAAs. Atherosclerosis rarely presents in the ascending aorta, in contrast to the abdominal aorta. The medial degeneration associated with TAAs is observed in the thoracic aorta with ageing, but this degeneration is qualitatively and quantitatively much greater in patients with TAAs [17, 29]. Medial degeneration in the TAA aorta is most commonly associated with loss of VSMCs and destruction of the medial elastic fibres. The intima and adventitia are thicker and the media thinner in the TAA aorta than in the control aortas [25, 29].

Ultimately our results showed that patients with aortoiliac atherosclerosis may be at greater risk of developing thoracoabdominal aortic aneurysms. This association was more prominent in male subjects aged over 65 years. However, in order to incorporate these preliminary findings into daily clinical practice, further studies should be carried out with larger sample sizes, long-term patient follow-up and survival analysis, while also considering other potential risk factors such as the patient's history of smoking, diabetes mellitus, hypertension and hyperlipidaemia.

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